PROGRAM facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Power Systems Advanced Research

09/2004

ADVANCED RESEARCH MATERIALS PROGRAM

Description

FE's Advanced Research (AR) Materials Program includes research being conducted in the AR Materials Program at Oak Ridge National Laboratory (ORNL) and other laboratories, as well as materials-related activities within the Office of Science and Technology at the National Energy Technology Laboratory (NETL). In addition, NETL's AR Materials Program works in conjunction with the National Metallurgical Research Program at Albany, Oregon. These activities focus on developing a technology base in the synthesis, processing, life-cycle analysis, and performance characterization of advanced materials. It funds exploratory research designed to develop new materials that have the potential to improve the performance or reduce the cost of existing fossil fuel technologies. The program also funds the development of materials for new systems and capabilities. Partnering and cost-sharing with industry are central components of this program.

The program emphasizes R&D directed toward solving materials issues for those advanced technologies being developed for coal and advanced power systems. The program is often described as cross-cutting in nature, because of the broad applicability to advanced fossil energy technologies.

Goal

The goal of the FE Advanced Research Materials Program is to provide a materials technology base to ensure the success of coal fuels and advanced power generation systems being pursued by DOE-FE. In efforts to meet this goal, the program is engaged in the following activities:

- Exploratory research designed to develop new materials, ideas, and concepts that have the potential to improve the performance or reduce the cost of existing fossil fuel technologies;
- Development of the materials of construction including processing and fabrication methods and functional materials necessary for those systems; and
- Partnering and cost-sharing with industry.

Program Focus Areas

The program addresses materials requirements for all fossil energy systems, including materials for coal-fueled technologies and advanced power generation technologies such as coal gasification, heat engines, combustion systems, and fuel cells. Projects have been broadly grouped into the following topic areas:

(1) High Temperature Applications, which includes materials that can perform at temperatures well over 1000°C;

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(2) *Ultra Supercritical and Gas Separation Systems*, which includes developing and ensuring the weldability of alloys for ultra supercritical (USC) steam systems in coal-fired boilers for power generation with operating temperatures raised to 1400 -1600° F, as well as membranes for hydrogen separation from coal derived synthesis gas;

(3) *Materials for Mercury Control*, focusing on evaluation of novel materials for the conversion or removal of mercury from process streams; and

(4) *Advanced Fuel Cell Concepts, devoted to exploring novel concepts and materials for fuel cells, including the possibility of using carbon derived from coal or other fossil sources directly as fuel.*

The emphasis in the program on technology transfer enhances U.S. technological competitiveness, not only in the fossil fuel area, but also in the materials industry and other technology application areas. Industrial partners, universities, non-profit agencies, and national laboratories conduct the research and this widespread participation helps maintain the U.S. materials technology capabilities.

Accomplishments:

- Among the membranes currently being developed with DOE/FE support, ORNL's inorganic microporous membrane with pore sizes less than 1 nm appears most promising (Figures 1 and 2). The ORNL membrane offers advantages over thin-film palladium membranes and ion-transport membranes (ITMs) for the separation of hydrogen from a mixed-gas stream. In microporous membranes such as the ORNL membrane, the flux is directly proportional to the pressure, whereas in palladium membranes it is proportional to the square root of the pressure while with ITMs, the flux varies as log P. Therefore, the ORNL microporous membrane becomes the more attractive option for systems that operate at increased pressure. The ORNL membrane provides adequate flux at warm-gas cleanup temperatures (~250ÚC). In collaboration with Pall Corporation, the membranes are now being laid on porous metallic supports in an effort to alleviate sealing problems.

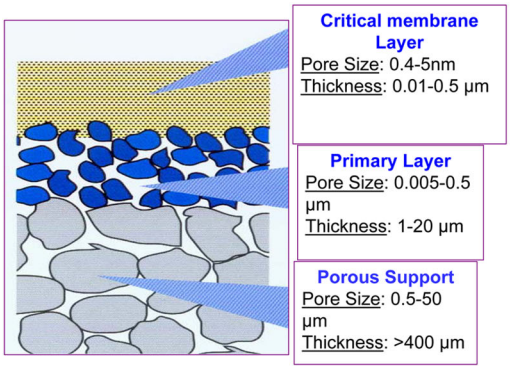

Figure 1: In the ORNL membrane, separation occurs at the critical separation layer with pore size less than 1 nm.

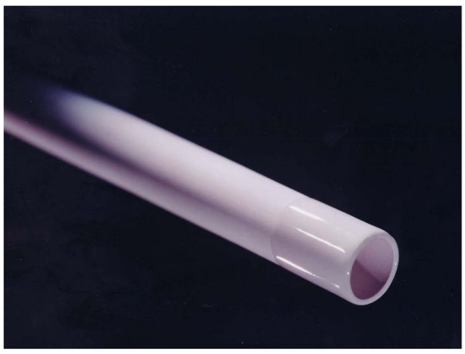

Figure 2: Tubular microporous membrane made at ORNL.

- A consortium which includes Energy Industries of Ohio, EPRI, four major US boiler manufacturers (Babcock & Wilcox Company, Riley Power, Foster Wheeler, and Alstom Power) and ORNL is conducting a 5-year materials development program to advance the technology in coal-fired power generation. The objective of this program, partially funded by the Department of Energy and the Ohio Coal Development Office, is to allow boiler operation at much higher temperatures and pressures than are presently used in conventional power plants. These higher operating conditions will enable the use of advanced, more efficient USC steam cycles in coal-fired power generation which offers the added advantage of reducing carbon dioxide emissions. As part of this development effort, new high–temperature, corrosion-resistant alloys have been fabricated into test loops and installed at the Reliant Energy power plant located in Niles, OH, in order to evaluate and qualify the materials for dependable operation in a hot corrosive coal-fired environment to produce steam up to 1400ºF and 5000 psi. (Figure 3)

Figure 3: Digital image showing the completed USC test loops prior to being delivered to the Niles plant for installation